Good correlation of goutallier rating of supraspinatus fatty changes on axial and reformatted parasagittal computed tomographic images

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Abstract: UNLABELLED Traumatic tendon tear of the rotator cuff occurs frequently and leads to fatty muscle infiltration. With regard to the outcome, fatty infiltration of the rotator cuff muscles constitutes a major negative predictive factor after rotator cuff surgery. In 1989, Goutallier et al established his classification system for assessment of fatty infiltration of the rotator cuff muscles. He used computed tomographic (CT) images in the axial plane. Today, the assessment of rotator cuff muscles on axial CT images has been widely replaced by assessment on parasagittal acquired magnetic resonance images. This change raised 2 important questions. First, there is a controversy whether the Goutallier classification can simply be adopted for magnetic resonance imaging. The second question is whether the muscle assessment in the axial plane is interchangeable with that in the parasagittal plane. We hypothesize that the assessment of fatty muscle infiltration is the same on reformatted parasagittal CT images as on axial CT images METHODS Three independent readers, 2 radiologists and one shoulder surgeon, rated fatty changes of the supraspinatus muscle on CT scans of 91 shoulders. Goutallier grades were assessed on axial and reformatted parasagittal CT images in 2 separate reading sessions. The paired t test was used to find differences between grading results on axial and reformatted parasagittal images. The Pearson correlation coefficient and weighted kappa statistics were used to quantify linear correlation, intrareader, and interreader agreement. RESULTS Mean (SD) Goutallier grading among all readers was 0.80 (1.16) (range, 0-4) on axial images and 0.89 (1.05) (range, 004) on parasagittal reconstructions. We detected a trend toward a slightly higher Goutallier grading on parasagittal reconstructions; however, this result was not significant ($P = 0.07$). The Pearson correlation coefficient was 0.702 ($P < 0.001$). Weighted kappa statistics indicated a moderately good to good intrareader (range of weighted kappa, 0.53-0.62) and interreader (weighted kappa, axial images, 0.55; reformatted parasagittal images, 0.65) agreement. CONCLUSION Grading of fatty infiltration of the supraspinatus muscle on parasagittal CT images is comparable with the standard Goutallier grading on axial images and is characterized by a moderately good to good intrareader and interreader agreement. Assessment of parasagittal images is characterized by a slightly higher interreader agreement and may therefore be the preferable modality.

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Good Correlation of Goutallier Rating of Supraspinatus Fatty Changes on Axial and Reformatted Parasagittal Computed Tomographic Images

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Traumatic tendon tear of the rotator cuff occurs frequently and leads to fatty muscle infiltration. With regard to the outcome, fatty infiltration of the rotator cuff muscles constitutes a major negative predictive factor after rotator cuff surgery. In 1989, Goutallier et al established his classification system for assessment of fatty infiltration of the rotator cuff muscles. He used computed tomographic (CT) images in the axial plane. Today, the assessment of rotator cuff muscles on axial CT images has been widely replaced by assessment on parasagittal acquired magnetic resonance images. This change raised 2 important questions. First, there is a controversy whether the Goutallier classification can simply be adopted for magnetic resonance imaging. The second question is whether the muscle assessment in the axial plane is interchangeable with that in the parasagittal plane. We hypothesize that the assessment of fatty muscle infiltration is the same on reformatted parasagittal CT images as on axial CT images

Methods: Three independent readers, 2 radiologists and one shoulder surgeon, rated fatty changes of the supraspinatus muscle on CT scans of 91 shoulders. Goutallier grades were assessed on axial and reformatted parasagittal CT images in 2 separate reading sessions. The paired *t* test was used to find differences between grading results on axial and reformatted parasagittal images. The Pearson correlation coefficient and weighted kappa statistics were used to quantify linear correlation, intrareader, and interreader agreement.

Results: Mean (SD) Goutallier grading among all readers was 0.80 (1.16) (range, 0–4) on axial images and 0.89 (1.05) (range, 004) on parasagittal reconstructions. We detected a trend toward a slightly higher Goutallier grading on parasagittal reconstructions; however, this result was not significant ($P = 0.07$). The Pearson correlation coefficient was 0.702 ($P < 0.001$). Weighted kappa statistics indicated a moderately good to good intrareader (range of weighted kappa, 0.53–0.62) and interreader (weighted kappa, axial images, 0.55; reformatted parasagittal images, 0.65) agreement.

Conclusion: Grading of fatty infiltration of the supraspinatus muscle on parasagittal CT images is comparable with the standard Goutallier grading on axial images and is characterized by a moderately good to good intrareader and interreader agreement. Assessment of parasagittal images is characterized by a slightly higher interreader agreement and may therefore be the preferable modality.

Key Words: supraspinatus muscle, fatty infiltration, Goutallier rating, computed tomography, axial plane, parasagittal plane

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Fatty infiltration of the rotator cuff muscles secondary to tendon tears is frequent[1–9] and constitutes a major negative predictive factor for optimal outcomes after rotator cuff surgery.[10–16] In 1989, Goutallier et al[6] established the most commonly used classification system for assessing fatty infiltration of the rotator cuff muscles using computed tomographic (CT) images in the axial plane. Currently, the assessment of rotator cuff muscles by axial CT images has been widely replaced by ultrasound examination or parasagittal acquired magnetic resonance (MR) images.[5,12,17–20] This change raised 2 important questions. First, there is a debate on whether the Goutallier classification can simply be extrapolated for MR imaging.[5,12] Second, the question has risen on whether results of muscle assessment in the axial plane are interchangeable with those done in the parasagittal plane. Fuchs et al[4] used the Goutallier classification to assess fatty infiltration of rotator cuff muscles on axial CT images with those performed in parasagittal MR images. The agreement between axial CT images and parasagittal MR images was only fair to moderately good. Therefore, it is necessary to determine whether these differences are due to the different imaging modalities or due to different imaging planes.

We hypothesize that the assessment of fatty muscle infiltration is the same on reformatted sagittal CT images as on axial CT images.

MATERIALS AND METHODS

Informed consent was obtained from all research subjects. We retrospectively analyzed 109 consecutive patients seen at an outpatient clinic specializing in shoulder orthopedic surgery. We included all patients undergoing CT examination upon indication of board-certified orthopedic surgeon for traumatic or degenerative conditions of the shoulder. The analyzed period was from January to November 2008. Eighteen patients had to be excluded because of prior shoulder surgery and metallic implants.

Computed Tomography

A 40-row CT scanner was used (Philips Brilliance 40, Philips Healthcare, Hamburg, Germany). All patients were examined using a standardized shoulder protocol (tube voltage, 140 kV; tube current, 300 mA s/slice; pitch factor, 0.426; matrix, 512 × 512; reconstruction thickness, 0.9 mm; and reconstruction increment, 0.45 mm). Computed tomographic images were acquired with the arm of the patient placed at the side of the body, the thumb pointing upward. Axial images were obtained from the superior aspect of the acromioclavicular joint to the inferior angle of the scapula. Reformatted parasagittal images (parallel to the glenoid joint surface) were reconstructed using a soft tissue kernel.

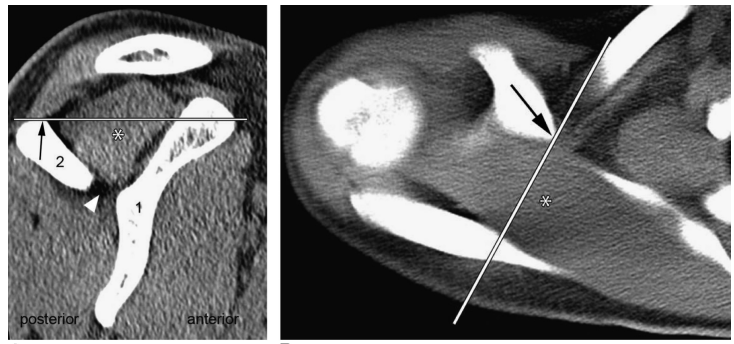

FIGURE 1. Reformatted parasagittal (A) and axial (B) CT images of the right shoulder of a 20-year-old male patient. In the parasagittal plane (A), grading of fatty infiltration of the supraspinatus muscle (*) was performed on the most lateral image on which there was no bony bridge (arrowhead) seen between the scapular body (1) and the scapular spine (2). In the axial plane (B), the rating was performed on the image touching the superior contour of the scapular spine (arrow on A and B) in the parasagittal image used for rating in the parasagittal plane (white bars). The supraspinatus muscle of this patient was rated zero on Goutallier in both planes by all readers.

Supraspinatus Muscle Evaluation

Fatty infiltration of the supraspinatus muscle was evaluated on specific images in the axial and reformatted parasagittal plane using a window center of 450 Hounsfield units (HU) and a window width of 2000 HU (Fig. 1).

In the parasagittal plane (Fig. 1A), grading of fatty infiltration of the supraspinatus muscle was performed on the first image from medial to lateral on which there was no more bony bridge between the scapular body and the scapular spine.

In the axial plane (Fig. 1B), the rating was performed on the last image from caudal to cranial were the projection line of the parasagittal image previously used for rating the parasagittal plane touching the superior contour of the scapular spine. We chose these planes because they are close to the planes used by Goutallier and Fuchs, and seem to be well reproducible.

The rating was performed by 3 independent and blinded readers (R), 2 radiology fellows (R1 and R2), and one senior orthopedic surgeon (R3) according to Goutallier et al.[6] Reading session occurred on 2 separate dates with a time interval of at least 6 weeks in between (Fig. 2). The order of the images was randomized for each reading session.

Statistical Analysis

The paired *t* test was used to determine statistical significance. The Pearson correlation coefficient was calculated to quantify linear correlation of grading results on axial and reformatted parasagittal images.

Weighted kappa values were calculated to assess intrareader and interreader agreement of Goutallier ratings in the axial and the parasagittal planes. Interval excluding 1 is significant. The analysis was performed using the R software (open source statistics program, Development Core Team 2009). $P < 0.05$ was considered statistically significant.

RESULTS

The mean age of the patients was 51 years (range, 20–87 years). There were 63 men (age range, 21–85 years) and 28 women (age range, 20–87 years).

There was a preponderance of Goutallier grades zero to 2. The median overall grading results of all 3 readers were Goutallier grade 1. The mean (SD) Goutallier grading on axial images among all 3 readers were 0.80 (1.16) (range, 0–4) and 0.89 (range, 0–4; SD 1.08) on parasagittal reconstructions. There was a trend toward a slightly higher Goutallier grading on parasagittal reconstructions; this result was however not significant ($P = 0.07$). The Pearson correlation statistics showed a good linear correlation of grading results on axial- and reformatted parasagittal images

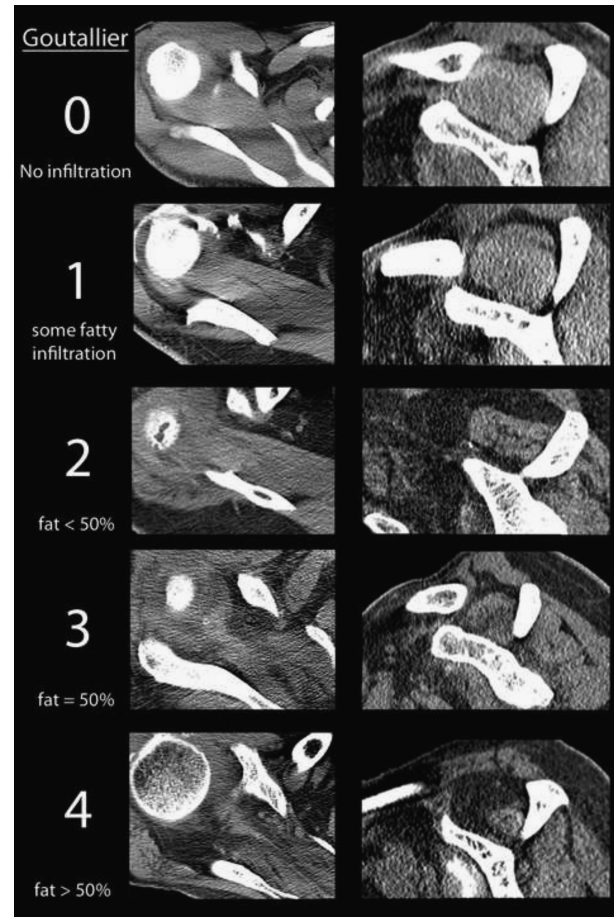

FIGURE 2. Goutallier grading. Examples for the different Goutallier grades. Left column, axial plane; right column, sagittal plane.

(Pearson correlation coefficient, 0.702; $P < 0.001$). The results of the 3 readers are summarized in Table 1.

Intrareader agreement between the assessments on axial and reformatted parasagittal images was moderately good to good[21] for all readers (Table 2); weighted kappa was 0.53 to 0.62. Reader 1 (R1) rated 56 (62%) of 91 patients identically on axial and parasagittal images, R2 rated 57 (63%) of 91 patients, and R3 rated 56 (62%) of 91 patients. In the other patients, Goutallier grading mostly differed by ±1 Goutallier grade (R1 differed 26 times [R1, n = 26] / R2, n = 25 / R3, n = 31). These differences occurred most often in the differentiation between Goutallier grades 0 and 1 (R1 differed 16 times [R1, n = 16] / R2, n = 15 / R3, n = 15).

Interreader agreement was moderately good to good[21] in both planes. Weighted kappa was 0.55 (95% confidence interval, 0.46–0.65) in the axial plane and 0.65 (confidence interval, 0.58–0.72) in the parasagittal plane.

DISCUSSION

Fatty infiltration of the rotator cuff muscles secondary to tendon tears is a major negative predictive factor for optimal outcomes after surgery.[2,12,17,22] In the diagnostic evaluation of rotator cuff tendons and muscles, CT has been largely replaced by ultrasound and magnetic resonance imaging.[5,12,17,19,20]

In previous studies, the agreement of Goutallier grading results on axial CT images and parasagittal MR images was fair to moderate.[4] Therefore, the objective of this study was to elucidate whether these discordant correlation results were due to the use of different imaging modalities or because of the different planes in which the rating was performed. Reasons for discordance in assessment of fatty infiltrations in different planes could be that one plane displays only the fatty degenerated part of the muscle or one plane displays only the healthy part of the muscle.

Our data demonstrate a moderately good to good agreement between Goutallier rating on axial and parasagittal CT images. This agreement is superior compared to previously published results by Fuchs et al[4] who compared Goutallier rating on axial CT images to parasagittal MR images and found a fair to moderate agreement. These findings seem to imply some disagreement due to the different imaging modalities and additionally some disagreement due to the different planes in which the evaluation was performed. However, because the intrareader agreement of each of the 3 readers was in the same order of magnitude as the interreader agreement, it can be concluded that the planes are interchangeable as the readers are. Furthermore, disagreements in the Goutallier rating of axial and parasagittal planes occurred mainly in the differentiation between Goutallier grades zero and 1. Both of these grades imply good muscle quality, and to date, the difference between these 2 grades may not be clinically important and has no clinical relevance. Our data further suggest that assessment of fatty infiltration in the parasagittal view has the advantage of a slightly superior interreader reproducibility.

The critical assessment of our study revealed 2 potential problems: First, we included 109 shoulders 18 of which we had to exclude. This corresponds to a high exclusion rate of 16.5%, but the exclusion of these cases was due to inevitable artifacts either due to previous surgery or metallic implants, so that a bias has not been introduced, but the conclusions are only applicable to patients without prior operations and metallic implants. Second, our patients tended to have low grades of fatty infiltration of the supraspinatus muscle (median grade, 1), but this corresponds to the frequency of changes observed in our clinical practice. Nevertheless, there were 13 patients with Goutallier grade 3 or 4 on axial images (grade 3, n = 9; and grade 4, n = 4) and 10 patients with Goutallier grade 3 or 4 on reformatted parasagittal images (grade 3, n = 8; and grade 4, n = 2).

TABLE 1. Grading Results of the 3 Readers

	Axial			Sagittal		
Goutallier Grade	**R1**	**R2**	**R3**	**R1**	**R2**	**R3**
0	53	60	44	41	47	43
1	20	16	23	28	25	21
2	5	6	9	9	9	20
3	7	6	13	8	8	7
4	6	3	2	5	2	0

R1, radiologist 1; R2 radiologist 2; R3, senior orthopedic surgeon.

We observed that both radiologists (R1 and R2) on sagittal CT images rated fewer grade zero and more grades 1 and 2, whereas the orthopedist rated more grade 2 and fewer grades 3 and 4 (Table 1). The authors discussed these findings and ruled systematic errors out. On the other hand, the data do not lead us to a conclusion.

We think that the sagittal CT image better demonstrates the fat infiltration that was not visible on the axial CT image because small fatty infiltrations are often in the lower part of the muscle. However, we do not have a hypothesis for the finding that the orthopedic surgeon rated more grade 2 and fewer grades 3 and 4. The sensitivity of all readers was in the same order of magnitude.

TABLE 2. Intrareader Agreement Between the Assessments on Axial and Reformatted Parasagittal Images

	Classic Goutallier Grading	
Reader	**Weighted Kappa**	**95% CI**
R1	0.56	0.41–0.67
R2	0.53	0.39–0.66
R3	0.62	0.50–0.72

95% CI, 95% confidence interval.

CONCLUSIONS

Grading of fatty infiltration of the supraspinatus muscle on parasagittal CT images is comparable with the standard Goutallier grading on axial images and is characterized by a moderately good to good intrareader and interreader agreement. Parasagittal assessment is characterized by a slightly higher interreader agreement and may therefore be a superior imaging modality.

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